

# GeneLab: “Omics” Data Systems for Space Biology Research

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<http://genelab.nasa.gov>





# Agenda



- I. Introduction**
- II. GeneLab Motivation**
- III. GeneLab Data Systems**
- IV. Summary**



# What is GeneLab?

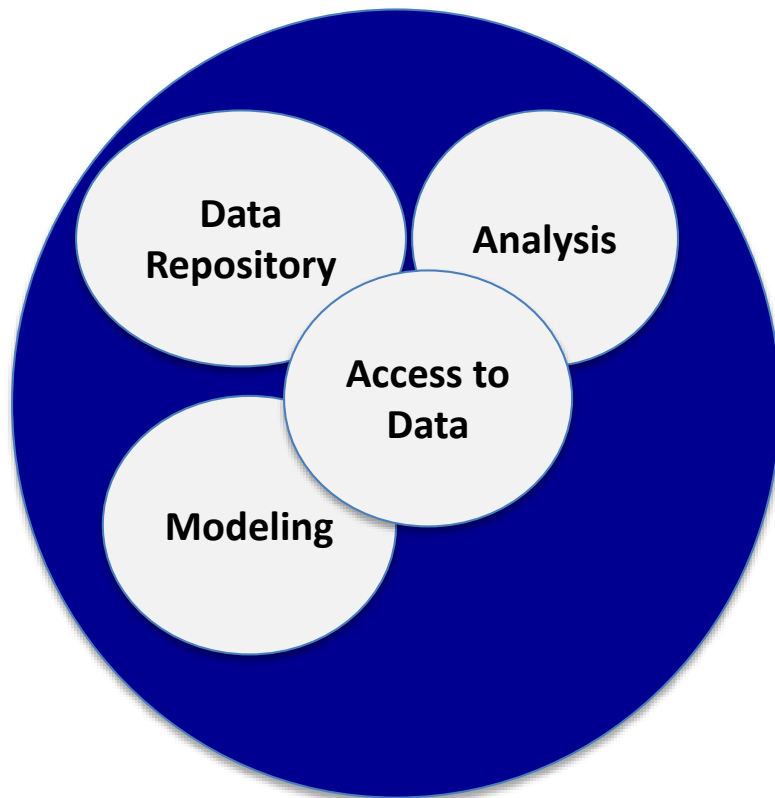
- new *systems approach* to space biology research
- open science and open data platform



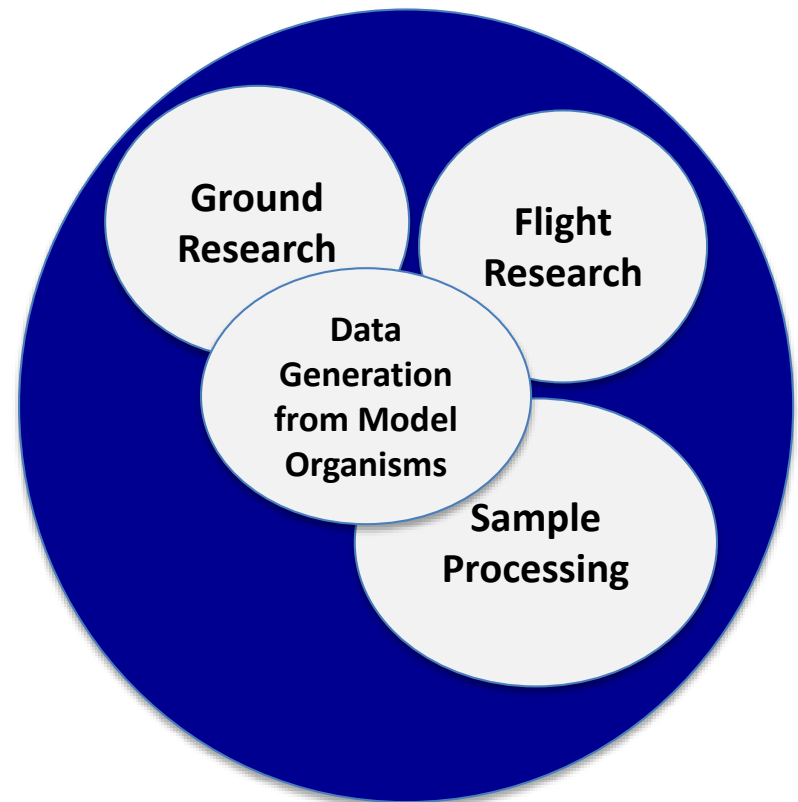
# GeneLab Structure



## Data Systems & Repository



## Research & Development





# GeneLab Motivations





# ISS Based Research



- New technologies to produce high quality Omics data from research missions aboard the ISS
- Limited access and high demand for the ISS platform
- Facilitate Systems biology to predict and/or mitigate changes due to microgravity



NASA astronaut Barry "Butch" Wilmore setting up the Rodent Research-1 Hardware in the Microgravity Science Glovebox aboard the International Space Station



# GeneLab Motivations



- Maximize ROI for ISS Utilization
- Create a PI Multiplier Effect
- Leverage NASA and External Partner Strengths
- Maximize Utilization of Cutting Edge Bioanalytical Tools and Techniques
- Speed the Pathway to Translation



# GeneLab Goals

1. Develop an integrated repository and bioinformatics data system
2. Enable the discovery and validation of molecular networks using next-generation omics technologies.
3. Engage the broadest possible community
4. Strengthen international partnerships





# Concept of Operations



## Experiment on ISS

Crew performs experimental protocol and harvests tissues.



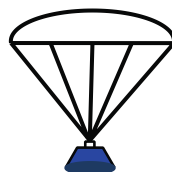
## Launch

Experiment is prepared and launched according to approved NRA.



## Return to Earth

Material sent back to earth for processing in investigators lab. Controls (ground and/or flight) processed at the same time.



## Data Sharing

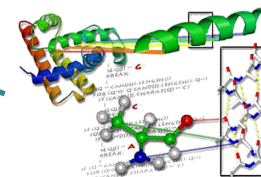
Data shared with larger scientific community. Results feedback to GeneLab and other databases accelerating scientific discovery by leveraging a bigger community.

## Next Generation Research

Iterative research solicitations for experiments utilizing GeneLab data for ground validation and next generation flight research.

## Process Samples

Extracted DNA, RNA and/or protein sent to validated omics center to generate sequence, transcript or protein expression data.



## Data Collection & Hosting

Data returned to investigator or GeneLab for analysis. Raw data uploaded into GeneLab database for public viewing.

## GeneLab Data Systems

## Modeling and Validation

Computational modeling and wet lab validation.



# Mission Types



Mission	Type	Definition	Example
<b>Dedicated</b>	<b>Reference Data</b>	Mission is entirely dedicated to GeneLab objectives; the Science Definition Team (SDT) defines the experiment and requirements; SDT is selected through the NASA Research Announcement process	TBD
<b>Collaborative</b>	<b>Data &amp; Sample Sharing</b>	GeneLab obtains specimens/samples from the existing PI space flight and ground control experiment	Rodent Research (Mouse)
	<b>Data &amp; Sample Augmentation</b>	GeneLab provides supplemental funding to a PI experiment to increase the quantity of specimens and perform processing to obtain dedicated sample; augmentation requires NASA SLPS experiment review approval process	BRIC-19 (plant), BRIC-20 (plant)  (BRIC=Biological Research in Canisters)
<b>Individual</b>	<b>PI Mission</b>	Funded and planned PI experiments	Data Submission



# Current Collaborative Missions



Year	Payload	Mission Type
2015	<b>BRIC-19</b> <b>Dr. Simon Gilroy</b> <b>University of Wisconsin-Madison</b> Space Biology NRA Award	<b>Augmentation, Plant</b>
	<b>BRIC-20</b> <b>Dr. Sarah Wyatt</b> <b>Ohio University</b> Space Biology NRA Award	<b>Augmentation, Plant</b>
	<b>RR-1</b> <b>Dr. Ruth Globus</b> <b>NASA</b> Validation Mission for Rodent Habitat	<b>Sample Sharing, Rodent</b>

(RR: Rodent Research ; BRIC: Biological Research In Canisters)



# GeneLab Data Systems



# GeneLab Phased Data Implementation



## Overview 2014-2021

Begin  
Implementation

**We Are Here**

Full  
Implementation

1.0

### Phase 1

Searchable Data  
FY2014 – 2015

### Phase 2

Data Acquisition  
FY2015-2016

### Phase 3

System Integration  
FY2017 – 2018

### Phase 4

Implementation  
FY2019 – 2021

#### GLDS

- Public website
- Searchable data repository

#### Science

- Pre-Flight validation, rodent proteomic profiling
- Collaborate with two flight experiments

#### GLDS

- Link to public databases

#### Science

- Data analysis from initial ground and flight studies

#### GLDS

- Integrated Platform

#### Science

- Outreach
- Dedicated flight experiments

- Community engagement

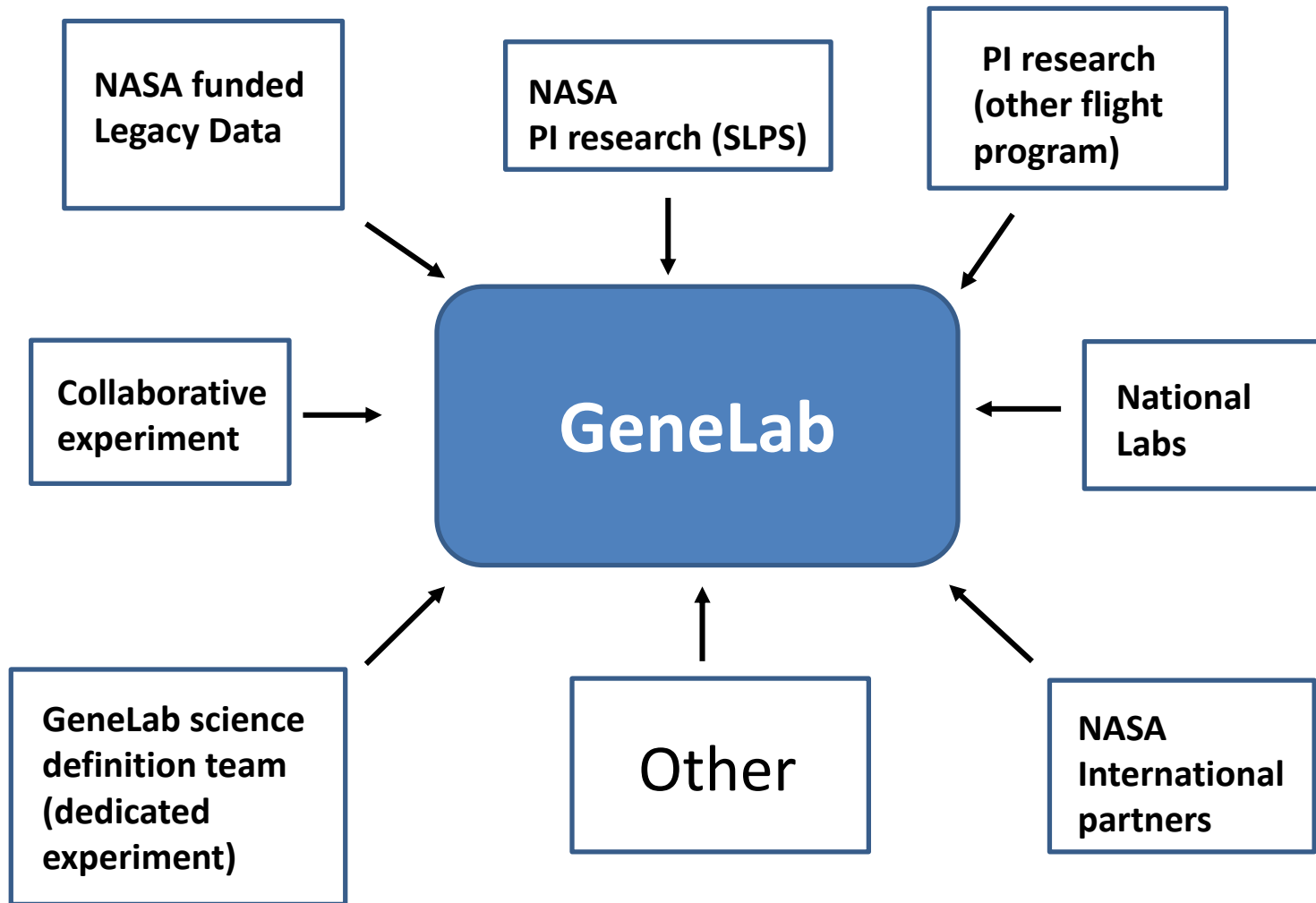
- Development of analytical and modeling tools

- Ongoing dedicated flight experiments





# Anticipated Sources of Data

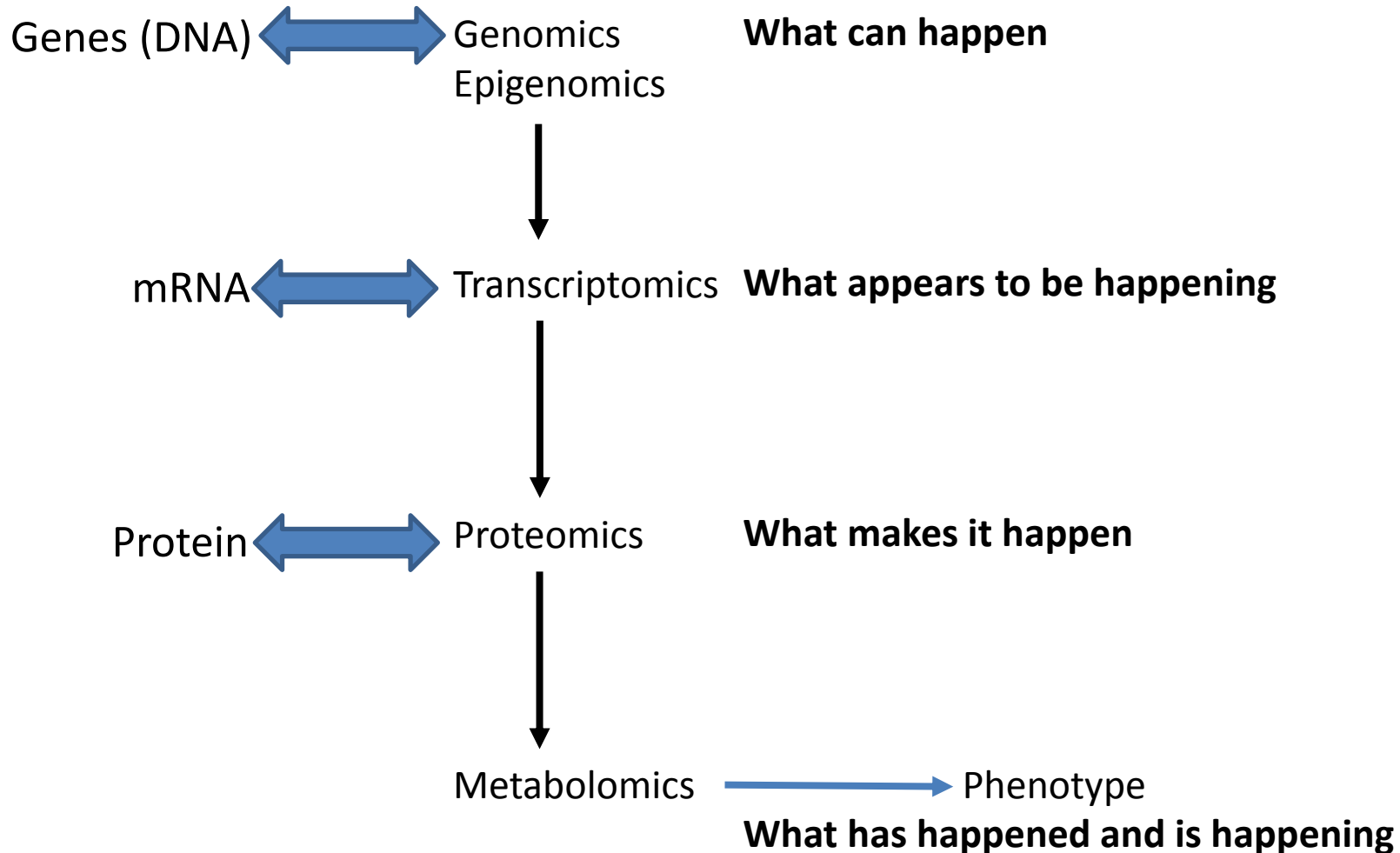




# Types of Analyses

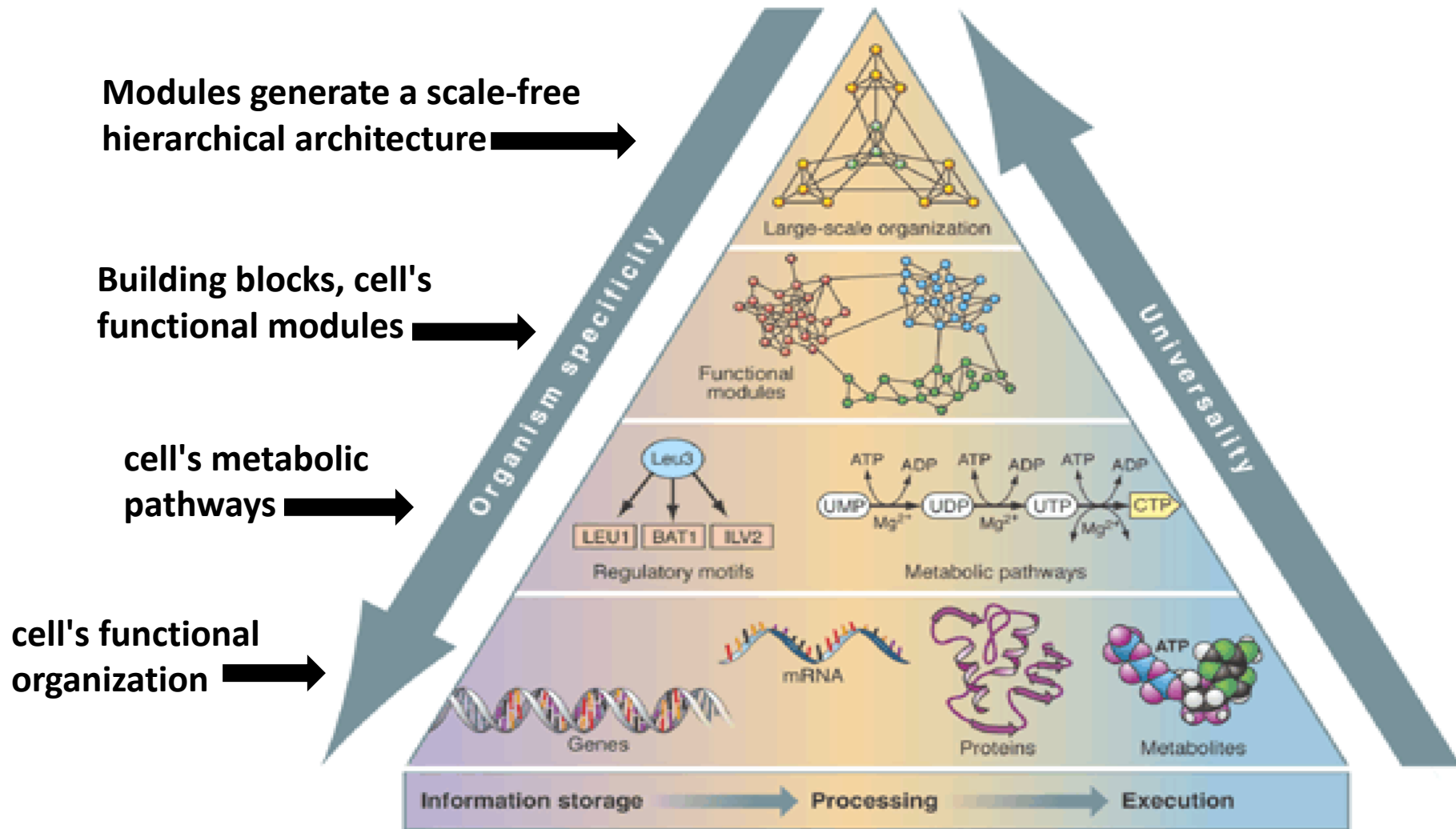
## Building Blocks of life

## Functional States





# Systems Biology



(from Oltvai-Barabasi, Science, Oct 02)



# GeneLab Data Systems v1.0

<http://genelab.nasa.gov/data>



- Omics Data Repository (22 dataset online)
- Basic study metadata search

GeneLab Open Science for Exploration

Home Data Submit Data Contact Us Search Data

All Studies page 1 of 1

**Effects of spaceflight on murine skeletal muscle gene expression**

Organisms	Factors	Assay Types	Release Date	Description
Mus musculus	Gravity	transcription profiling	Dec-26-2008	Spaceflight results in a number of adaptations to skeletal muscle, including atrophy and shifts towards faster muscle fiber types. To identify changes in gene expression that may underlie these adaptations, microarray expression analysis was...

**Root transcriptome remodeling of Arabidopsis in response to high levels of magnesium sulfate**

Organisms	Factors	Assay Types	Release Date	Description
Arabidopsis thaliana	treatment time genotype treatment	transcription profiling	Sep-17-2010	Martian regolith (unconsolidated surface material) is a potential medium for plant growth in bioregenerative life support systems during manned missions on Mars. However, hydrated magnesium sulfate mineral levels in the regolith of Mars can...

**Candida albicans response to spaceflight (NASA STS-115)**

Organisms	Factors	Assay Types	Release Date	Description
Candida albicans	growth condition	transcription profiling	Nov-01-2013	This study presents the first global transcriptional profiling and phenotypic characterization of the major human opportunistic fungal pathogen, <i>Candida albicans</i> , grown in spaceflight conditions. Microarray analysis revealed that <i>C. albicans</i> ...

**Transcription profiling of rat to study the effect of hindlimb unloading on healing of medial collateral ligaments 3 weeks after injury**

Organisms	Factors	Assay Types	Release Date	Description
Rattus norvegicus	protocol type clinical treatment	transcription profiling	Mar-10-2004	A recent physiological study established that hindlimb unloading of rats at 3 and 7 weeks inhibits healing of injured ligaments, resulting in a badly aligned, discontinuous collagen matrix. Using tissue from these rats, we focused on the 3-...

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2 search results for "PAO1"

**Response of Pseudomonas aeruginosa PAO1 to low shear modeled microgravity**

Organisms	Factors	Assay Types	Release Date	Description
Pseudomonas aeruginosa	culture	transcription profiling	Jul-29-2010	Anticipating the risk for infectious disease during space exploration and habitation is a critical factor to ensure safety, health and performance of the crewmembers. As a ubiquitous environmental organism that is occasionally part of the human...

**Transcriptional and proteomic response of Pseudomonas aeruginosa PAO1 to spaceflight conditions involves Hfq regulation and reveals a role for oxygen**

Organisms	Factors	Assay Types	Release Date	Description
Pseudomonas aeruginosa PAO1	culture	transcription profiling	Jun-28-2011	Characterization of bacterial behavior in the microgravity environment of spaceflight is of importance towards risk assessment and prevention of infectious disease during long-term missions. Further, this research field unveils new insights.

<http://genelab.nasa.gov>




# GeneLab Data Systems v1.0

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- Omics Data Repository
- Basic study metadata search
- Study metadata display

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Transcriptional and proteomic response of *Pseudomonas aeruginosa* PAO1 to spaceflight conditions involves Hfq regulation and reveals a role for oxygen

**2 Datasets available:**  
Microarray Data Files  
ISA-TAB Metadata file

GeneLab Accession Number	GLDS-15																																																
Source Accession Number	E-GEOD-22684																																																
Contacts	<table><thead><tr><th>Name</th><th>Role</th><th>Organization</th><th>Email</th></tr></thead><tbody><tr><td>Pieter Monsieus</td><td>submitter</td><td></td><td></td></tr><tr><td>Aur�lie Crabb�</td><td></td><td></td><td></td></tr><tr><td>Michael Schurr</td><td></td><td></td><td></td></tr><tr><td>Pieter Monsieus</td><td></td><td></td><td></td></tr><tr><td>Lisa Morici</td><td></td><td></td><td></td></tr><tr><td>Jill Schurr</td><td></td><td></td><td></td></tr><tr><td>James Wilson</td><td></td><td></td><td></td></tr><tr><td>Mark Ott</td><td></td><td></td><td></td></tr><tr><td>George Tsapralis</td><td></td><td></td><td></td></tr><tr><td>Heidi Stefanyshyn-Piper</td><td></td><td></td><td></td></tr><tr><td>Cheryl Nickerson</td><td></td><td></td><td></td></tr></tbody></table>	Name	Role	Organization	Email	Pieter Monsieus	submitter			Aur�lie Crabb�				Michael Schurr				Pieter Monsieus				Lisa Morici				Jill Schurr				James Wilson				Mark Ott				George Tsapralis				Heidi Stefanyshyn-Piper				Cheryl Nickerson			
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<http://genelab.nasa.gov>

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Study Design Factor(s)	Factor	Ontology: Concept															
	culture	cell culture															
Assay(s)	Assay Type	Device Type	Device Platform														
	transcription profiling	DNA microarray															
Project	<table><tr><td>Project Identifier</td><td>Microbe</td></tr><tr><td>Project Link</td><td><a href="http://lsda.jsc.nasa.gov/scripts/experiment/exper.aspx?exp_index=1329">http://lsda.jsc.nasa.gov/scripts/experiment/exper.aspx?exp_index=1329</a></td></tr><tr><td>Project Type</td><td>Flight</td></tr><tr><td>Flight Program</td><td>Space Shuttle</td></tr><tr><td>Experiment Platform</td><td>Shuttle Life Sciences Research (Middeck), Group Activation Packs (GAPS)</td></tr><tr><td>Space Program</td><td>NASA</td></tr><tr><td>Managing NASA Center</td><td>Ames Research Center (ARC)</td></tr></table>			Project Identifier	Microbe	Project Link	<a href="http://lsda.jsc.nasa.gov/scripts/experiment/exper.aspx?exp_index=1329">http://lsda.jsc.nasa.gov/scripts/experiment/exper.aspx?exp_index=1329</a>	Project Type	Flight	Flight Program	Space Shuttle	Experiment Platform	Shuttle Life Sciences Research (Middeck), Group Activation Packs (GAPS)	Space Program	NASA	Managing NASA Center	Ames Research Center (ARC)
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Publications	Crabb� A, Schurr MJ, Monsieus P, Morici L, Schurr J, Wilson JW, Ott CM, Tsapralis G, Pierson DL, Stefanyshyn-Piper H, Nickerson CA. Transcriptional and proteomic responses of <i>Pseudomonas aeruginosa</i> PAO1 to spaceflight conditions involve Hfq regulation and reveal a role for oxygen. PubMed ID 21169425, DOI 21169425																





# GeneLab Data Systems v1.0

<http://genelab.nasa.gov/data>



- Omics Data Repository
- Basic study metadata search
- Study metadata display
- Data retrieval

DEMO

The screenshot shows the GeneLab website interface. At the top, there is a navigation bar with links: Home, Data, Submit Data, Contact Us, and Search Data. A search bar is located to the right of the Search Data link. Below the navigation bar, the main content area displays the title "Datasets for Study: Transcriptional and proteomic response of Pseudomonas aerugi...". Under this title, there are two sections. The first section is titled "Microarray Data Files" and includes a description: "Microarray Data Files Compressed collection of raw or processed data files associated with this study. Formats are platform specific. Please view the associated ISA-TAB metadata files to get formatting details." Below this description, there is a link for "File Download Links: GLDS-15\_microarray\_E-GEOD-22684.raw.1.zip ( 5733111 bytes )". The second section is titled "ISA-TAB Metadata file" and includes a description: "ISA-TAB Metadata file ISA-TAB is the metadata collection format utilized by GeneLab. Further description and tools can be found at www.isa-tools.org". Below this description, there is a link for "File Download Links: GLDS-15\_metadata\_E-GEOD-22684.zip ( 8177 bytes )".

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Home Data Submit Data Contact Us Search Data  Q

Datasets for Study: [Transcriptional and proteomic response of Pseudomonas aerugi...](#)

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Microarray Data Files Compressed collection of raw or processed data files associated with this study. Formats are platform specific. Please view the associated ISA-TAB metadata files to get formatting details.

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# Summary



- GeneLab will serve as an open access database containing “Omic” datasets for model organisms relevant to spaceflight, allowing cross-species comparison
- Will provide a tool for basic research to translate into discovery utilizing ISS research



# Call to Action

- **Visit** the gene lab site: <http://genelab.nasa.gov>
- **Sign up** for the gene lab mailing list  
at: <http://genelab.nasa.gov/community.html>
- **Share/Submit** your data sets:  
<http://genelab.nasa.gov/data/>



# Acknowledgements



## **Ames GeneLab Team**

Richard S. Thompson

Nikita Gilkerson

Linda Timucin

Yung Nguyen

Oana Marcu

## **Ames Rodent Research**

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Ruth Globus

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## **University of Wisconsin-Madison**

Simon Gilroy